

SPIKING + OJA + LCA = IMAGE COMPREHENSION AND COMPRESSION  
 EQUATIONS GOVERNING OUR 2 MONTHS AT THE DARPA INNOVATION HOUSE IN ARLINGTON, VA

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**Average firing counts over interval  $\tau$ :**

$$n_j^\tau(t + \Delta t) = e^{\frac{-\Delta t}{\tau}} \left[ A_j(t) + n_j^\tau(t) \right] \quad (1)$$

**Average firing rate over interval  $\tau$ :**

$$f_i^\tau(t) = \frac{n_i^\tau(t)}{\tau} \quad (2)$$

**Feed-forward weight adaptation:**

$$\begin{aligned} \Delta Q(t) &= \beta \{ [Oja] \cdot [STDP] - decay \} \\ Q_{ij}(t + \Delta t) &= Q_{ij}(t) + \beta \{ \\ &f_{Y_j}^{\tau_{oja}}(t) \left[ f_{X_i}^{\tau_{oja}}(t) - Q_{ij}(t) f_{Y_j}^{\tau_{oja}}(t) \right] \cdot \\ &\left[ \lambda_P A_Y(t) n_{X_i}^{\tau_P}(t) - \lambda_D A_{X_i}(t) n_{Y_j}^{\tau_D}(t) \right] - \\ &\alpha_{dec} Q_{ij}(t) \} \end{aligned} \quad (3)$$

where  $\beta$  is a learning rate:

$$\beta = dwMax \cdot \frac{\Delta t}{\tau_{oja} f_o}$$

**Neuron adaptive firing threshold:**

$$V_j^{th} = V_j^{adpt} + e^{\frac{-\Delta t}{\tau_{V_{th}}}} \left( V_j^{th} - V_j^{adpt} \right) \quad (4)$$

where

$$\begin{aligned} V_j^{adpt}(0) &= V_j^{thRest} \\ V_j^{adpt}(t + \Delta t) &= V_j^{adpt}(t) + \frac{\Delta t}{\tau_{THR}} \left[ f_j^{\tau_o}(t) - f_o \right] \frac{V_{scale}}{f_o} \end{aligned} \quad (5)$$

**Lateral inhibition:**

$$w_{jk}(t + \Delta t) = \frac{\Delta t}{\tau_{INH}} \left[ f_j^{\tau_{LCA}}(t) f_k^{\tau_{LCA}}(t) - f_o^2 \right] \frac{1}{f_o^2} \quad (6)$$

**Current scales for  $\tau$  values**

$$\tau_{oja} \approx 50 - 200ms$$

$$\tau_P \approx 10 - 20ms$$

$$\tau_D \approx 20 - 40ms$$

$$\tau_{LCA} \approx \tau_{oja}$$

$$\tau_o = \frac{1}{f_o}$$

$$\tau_{THR} \gg \tau_o$$

$$\tau_{INH} \gg \tau_{LCA}$$

$$\tau_{V_{th}} \approx 5ms$$

**Current values for constants:**

$$V_{thRest} = -55mV$$

$$V_{rest} = -70mV$$

$$V_{scale} \approx V_{thRest} - V_{rest}$$